DBP: BROMATE

FACT SHEET

See related Fact Sheets: Acronyms & Abbreviations; Glossary of Terms; Cost Assumptions; Raw Water Composition; Total Plant Costs; and WaTER Program.

Disinfection By-Products include Bromate, Chlorite, HAAs, and THMs.

1. CONTAMINANT DATA

A. Chemical Data: Bromate (BrO_3^-) is primarily the result of disinfection with ozone. Bromate is an inorganic ion which is tasteless, colorless and has a low volatility. Bromate dissolves easily in water and is fairly stable. MW = 127.90 g/mol.

B. Source in Nature: Bromate is not typically derived from natural sources. It forms when ozone reacts with the naturally occurring bromide ion commonly found in raw water supplies such as streams, lakes and reservoirs. The amount of bromate formed is influenced by the quantity of bromide in the water.

C. SDWA Limits: Bromate is one of four regulated disinfection by-products (DBPs). The MCL for bromate is 0.01 mg/L (annual average). Significant monitoring requirements are also included in the SDWA regulations.

D. Health Effects of Contamination: Short-term exposure to bromate at levels above the MCL has not been shown to cause ill health effects. At long-term exposure levels above the MCL, bromate may increase the risk of cancer.

2. REMOVAL/REDUCTION TECHNIQUES

Bromate control focuses primarily on:
- Reducing the oxidant demand (e.g. NOM removal), and consequential reduction in dosage applied.
- Source water selection
- Optimization of the disinfection process
- pH decrease and ammonia addition

The removal of bromate is usually a final solution when other methods can not achieve required reductions.

A. USEPA BAT:
- Enhanced coagulation and media filtration for NOM removal uses the conventional treatment processes of chemical addition, coagulation, and dual media filtration. Benefits: low capital costs for proven, reliable process. Limitations: operator care required with chemical usage; sludge disposal.
- A granular activated carbon (GAC) filter can be used to remove NOM. GAC uses extremely porous carbon media in a process known as adsorption. As water passes through the media, the dissolved contaminants are attracted and held (adsorbed) on the solid surface. Benefits: well established; suitable for home use. Limitations: effectiveness based on contaminant type, concentration, rate of water usage, and type of carbon used; requires careful monitoring.

Optimization of the Disinfection Process
The type and location of disinfection can greatly affect the amount of bromate formed. This must always be checked against providing required CT values. Moving the ozonation point to a location following a NOM removal process (e.g. coagulation) will reduce the ozone demand. Staging the ozonation with ozone addition in smaller doses from multiple locations can reduce the ozone to DOC and ozone to bromide ratio, and consequently reduce the bromate formation. Reducing the pH will lower the bromate formation, but will increase the brominated organic compound formation. The addition of ammonia or hydrogen peroxide can also decrease bromate formation.

B. Alternative Methods of Treatment:
NOM Removal
- Enhanced coagulation and microfiltration (MF) or ultrafiltration (UF) for NOM removal uses the membrane filtration of coagulated NOM. Benefits: low capital costs for fairly new, but proven process. Limitations: higher operator care than for sand filtration, higher O&M costs.
- Nanofiltration (NF) for NOM removal uses the membrane to physically separate the NOM from the water. Benefits: less operator care than with coagulation and microfiltration, consistent low NOM product water. Limitations: membrane fouling, operator care, higher O&M costs than microfiltration, concentrate disposal.
- Reverse osmosis (RO) for dissolved NOM removal uses a semipermeable membrane and high pressure pump to cause the water, but not suspended or dissolved solids NOM to pass through the membrane. Benefits: produces high quality water. Limitations: high cost; membrane fouling, pretreatment/feed pump requirements; concentrate disposal.

B. Alternative Methods of Treatment: (cont)

NOM Removal

- Lime softening uses $Ca(OH)_2$ in sufficient quantity to raise the pH to about 10 to precipitate carbonate hardness and trap NOM in the process. Benefits: lower capital costs; proven and reliable. Limitations: operator care required with chemical usage; sludge disposal. pH readjustment needed.

Source Water Selection

The selection of a source water, when possible, can significantly reduce bromate formation. The quantity and type of NOM in the source water impacts the amount of bromate formed. The amount of bromide and pH will also affect the amount of bromate formed.

Bromate Removal

- RO is also effective for bromate removal (see "NOM Removal" section above).

Alternate Disinfection Process

When process modifications fail to reduce bromate levels sufficiently, changing the disinfection process to a chlorine based system such as free chlorine or chlorine dioxide is an option. However, there are associated DBPs with these processes. Switching to UV disinfection eliminates all bromate formation. A disinfectant residual using chloramines or free chlorine still needs to be provided in the distribution system for UV treatment.

C. Safety and Health Requirements for Treatment Processes: Personnel involved with demineralization treatment processes should be aware of the chemicals being used (MSDS information), the electrical shock hazards, and the hydraulic pressures required to operate the equipment. General industry safety, health, and self protection practices should be followed, including proper use of tools.

3. PROCESS DESCRIPTIONS AND COST DATA

General Assumptions: Refer to: Raw Water Composition Fact Sheet for ionic concentrations; and Cost Assumptions Fact Sheet for cost index data and process assumptions. All costs are based on *ENR*, PPI, and BLS cost indices for March 2001. General sitework, building, external pumps/piping, pretreatment, or off-site sludge disposal are not included.

Refer to pages 9 of 12 through 12 of 12 for process descriptions and cost data.

4. REFERENCES

USEPA BAT (Coagulation, GAC, Optimization):

http://www.epa.gov/safewater/mdbp/stage1dbprwhatdoesitmeantoyou.pdf

USEPA. The Stage 1 Disinfectants and Disinfection Byproducts Rule, What Does it Mean to You. EPA 816-R-01-014. June 2001.

http://www.epa.gov/OGWDW/mdbp/dbpfr.html

USEPA. National Primary Drinking Water Regulations: Disinfectants and Disinfection Byproducts; Final Rule. RIN 2040-AB82. 40 CFR Parts 9, 141, and 142. Section II E. December 1998.